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## THE MEDULLARY RAY AS AN ELEMENT OF STRENGTH IN STRUCTURAL TIMBER.

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IN the growth of the exogenous tree, the prime function of the medullary ray, as is well known, is the distribution of the elaborated foodstuffs to the active cells in the living zone, or sap-wood, as it is called.

As the successive annual layers are added and the protoplasm migrates outward, leaving the cells empty, these pith rays eventually harden into plates radiating outward in every direction from the heart of the stem to the bark, apparently forming part of the stiffening framework or mechanical support of the tree.

Whether or not the pith ray is really an element of strength is a much disputed question. Since most of the ruptures or radial cracks that occur in seasoning a section of an entire log are found to be either in the middle of a pith ray or immediately adjacent, many are led to believe that the pith ray is the weaker element.

There is a very apparent difference in the shrinkage of a tangential section or along the annual layers over that of the radial section, or in the direction of the medullary ray. This is accounted for in various ways by the different writers on the subject. The reason that seems to me to be the most logical is, in substance, as follows:

The shrinkage is directly due to the fact that as a section of wood gives up its moisture the walls of each individual cell become thinner, its diameter smaller, and as a consequence the piece as a whole shares in this diminution of size. Since the length of a fiber is a great many times its diameter, the effect of this contraction along the length of the fiber is inappreciable. The cells of the medullary rays have their length at right angles to the direction of the wood fibers, and this opposition prevents the latter from shrinking as much as they otherwise would, while between the rays or in the direction of the annual layers they are left free to contract as they will. With this theory in mind the first experiments were made.

Since hygroscopicity makes the expansion of dry wood-fibers by the absorption of moisture practically equal to the contraction of unseasoned wood by the evaporation of its moisture, this was made use of for the sake of making comparisons in the first experiments. Pieces of equally dry wood were cut to exactly the same dimensions,

with the longest dimension in each case running across the grain of the wood. In the one the medullary rays ran in direction of the length of the piece and in the other at right angles to it. Together these were immersed in warm water, and when saturated were taken out and measured. It was found that the total expansion of the piece with the rays perpendicular to its length was fully four times as great as in the one with the rays parallel. This test being made with white oak this difference is probably abnormally high. It is found that the ratio of difference prevailing in most of our woods is about three to two. In this case the medullary ray seems to be able to resist the natural forces resulting from the expansion or contraction. The question then arises, "Can the medullary ray in a like degree resist such external forces as may be brought to bear upon the timber?"

In order to answer this question a number of tests were made with various woods. The following are the principal tests made: Longitudinal shear, deflection or cross-bending, resistance to cleavage and compression or crushing across the grain.

In the longitudinal shear test one-half of the specimens were prepared with mortises running through the stick parallel to the pith rays, the other half with the mortises perpendicular to the rays. The average result of all the pieces showed a small per cent. of difference in favor of the ray.

For the cross-bending test a piece of wood was sawed out so that the rays would be exactly parallel to two faces and at right angles to the other two. This stick was then sawed in two and each half tested separately, the first with the ray parallel to the lines of force and the second at right angles. The results of this test showed that the piece with the rays presented edgewise to the load was able to support fifteen per cent. more for a given deflection, all other things being equal, than the piece with the flat side of the ray to the load.

In testing the resistance to cleavage, where the lines of force run parallel to the ray the resistance was approximately 1500 pounds to the square inch. With the opposite position the average was less than 500 pounds per square inch, and in each instance in the latter tests the failure occurred in one of the rays, showing that to at least one force the medullary ray yields before the fibro-vascular tissue does.

It was in the compression tests that the greatest difference was manifest. For this test the blocks were cut to exactly the same dimensions, the difference being that in one set the rays were vertical and in the other set horizontal. They were taken one at a time

and subjected to a steady crushing force until a definite rupture occurred. In the pieces tested with the rays parallel to the crushing force the average resistance per square inch was 3750, the failure occurring between the rays. With the other set, where the force was at right angles to the rays, the piece was held together by the rays until a pressure of 12,000 pounds per square inch was reached, or a little better than three times that of the former.

Structural timbers are being constantly tested in their ability to resist these forces, and if there is any virtue in placing a timber in a certain position in relation to the load it is to be subjected to it should be known.

It is not expected that these tests will be accepted as conclusive and final, but that the results of the experiments herein described give evidence that the medullary ray as an element of strength in structural timbers is well worthy of consideration and will invite further investigation.